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CERTAIN OTORHINOLARYNGOLOGICAL PROBLEMS IN MEDICAL SUPPORT OF SPACE FLIGHTS

by

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The problem of the further conquest of space is continuously connected with /1* the development of space medicine. Problems related to a whole series of clinical disciplines, including otorhinolarygology, are of great importance for the biomedical support of manned space flights.

Solving problems in the area of otorhinolaryngology in essence is related to all stages of medical support of space flights. Here, each of these stages (namely, selection and training, space flight, and even the post-flight period), while having their own individual characteristics, [also] determines the specifics of otorhinolaryngological problems, either as purely clinical [research] or in the course of a definite trend of scientific research.

Yet, the main trends, among the most important problems of otorhinolaryngology in space medicine, have become defined, i.e.: vestibulology, acoustics, and purely clinical otorhinolaryngological aspects (prophylaxis, diagnosis and treatment of otorhinolaryngological diseases).

After the first manned flights in space, in the early stages of the formation of space medicine, problems of space vestibulology attracted great attention from domestic and [Soviet] foreign researchers.

As is well-known, vestibular-vegetative disorders are a not infrequent occurrence which was observed in cosmonauts from many space expeditions, among them the crew of Skylab-2 (Allan Bean, Jack Lousma, and Owen Garriott).

This situation is motivating scientists of many countries to direct their ef- /2 forts toward the study of the pathophysiological mechanisms of the observed disorders.

Many hypotheses concerning the pathogenesis of vestibular-vegetative disorders in space flight now exist. They attempt to explain the above-mentioned disorders

* Numbers in the margin indicate pagination in the foreign text.

either as the effect of weightlessness as a specific stimulus, or the result of a disruption of the interrelationship of the otolithic and cupular systems during weightlessness, or as the result of changes in the afferent systems of the organism (M. D. Yemel'yanov, 1968; G. L. Komendantov, 1963; K. L. Khilov, 1964; Ye. M. Yuganov, 1968; Graybiel, 1971; Reason, 1967; Steele, 1967, et al).

While not attempting to analyze each of these hypotheses, we would like to note that all of them still need thorough testing by the further accumulation of factual information, received ~~during the conduction of~~ from special simulation experiments and observations made directly during space flights.

An important step in this direction was made, as is known, by American scientists in one of the scientific programs of Skylab. However, one should also point out that, at this time, in the course of further searching for the solution to the vestibular problem, much information has already been acquired which allows one to approach evaluation of mechanisms of vestibular-vegetative disorders from a somewhat different position, namely, taking into consideration the general adaptive reactions of the organism to weightlessness. This concerns first of all the redistribution of the general circulating volume of blood in weightlessness and the subsequent appearance of hemodynamic changes, disorders of the water-salt exchange, and also other functional shifts, elucidated in detail in the domestic and foreign literature (O. G. Gazenko, A. A. Gyurdzhian, 1964; L. I. Kakurin, 1972; Berry, 1969, 1973 Leach et al., 1973; and others). /3

Hemodynamic disorders with definite microcirculatory disturbances at the tissue and intracellular level, hemostasis in the cerebral vessels, [and] water-salt exchange disorders with tissue dysbalances in potassium, calcium and sodium ions determine the most favorable conditions for the development of vestibular-vegetative disorders during weightlessness. Against this [well-] prepared background, the likihood of the development of pronounced vestibular-vegetative reactions even to threshold and sub-threshold stimuli, evoked by head and body movements in space flight, is completely possible. Thus, a [very] real precondition is created for the formation of

a pathophysiological mechanism, which from the positions of otoneurological practice on earth can be interpreted as a Meniere-like crisis or as a vestibulopathic seizure.

It is indeed notable that vestibular-vegetative disorders arising during space flight immediately follow hemodynamic changes. They begin not immediately during "entry" into weightlessness, but with the appearance of a "rush" of blood to the head and gradually subside as the organism adapts to these conditions. In human ground-based experiments with a mechanism simulating redistribution of blood during so-called anti-orthostatic hypokinesia, a series of authors (K. L. Khilov et al., 1969; E. V. Lapayev, N. V. Platonov, 1973; and others) have observed functional disorders of the vestibular analysor (manifested in some subjects as spontaneous nystagmus and the onset of nausea during abrupt movement of the head) precisely in the first days of adaptation. This information can serve as definite proof of the single-directedness of the main mechanisms in the pathogenesis of the observed vestibular-vegetative disorders in space flight. 4

In this connection, it is appropriate to note yet another aspect of the interrelationship between the vestibular analysor and hemodynamic reactions of the cardiovascular system. Namely, we have in mind changes in hemodynamic indices during vestibular stimulation and, in particular, regularities, evidencing not only the hemodynamics in response to adequate stimulation of the vestibular analysor (I. I. Bryanov et al; 1966; N. A. Razsolov, 1966; E. V. Lapayev and Ye. M. Yuganov, 1968; A. A. Chirkov, 1969, 1971; and others as is well-known, hemodynamic disorders during vestibular stimulation are sometimes more pronounced, the less vestibular stability possessed by the experimental subject. Moreover, the more significantly the vestibular instability is pronounced and the stronger the manifestation of vestibular-vegetative disorders, the more pronounced are the hemodynamic changes. In their extreme manifestation, these changes resemble pre-collapse and collaptoid states.

On the other hand, in vestibularly stable subjects, even a very intensive

and prolonged influence does not evoke significant changes in the hemodynamics.

As is well-known, many authors do not share the viewpoint that there is a direct relationship between the resistance of the vestibular apparatus to the influence of adequate stimuli, as applied under ground-based conditions, and tolerance to flight. Yet, all previous experience of flights on the spacecraft Vostok, Voskhod, and Soyuz allows one to assume that persons who are by nature resistant to the cumulative effect of adequate stimuli, as well as persons trained for not just one but a complex of adequate stimuli, possess hemodynamic stability during /5
vestibular stimulation, endure space flight without vegetative disorders, and adapt more easily to weightlessness.

Thus, the explanation of the possibility for the development of vestibular-vegetative disorders against the background of the organism's adaptive reactions to blood redistribution and weightlessness substantiates the pathogenetic connection between these processes. This allows one to outline several ways of implementing a number of specific measures for treatment and prophylaxis, and to determine the position of the expert medical commision on the questions of selection and training of cosmonauts. In particular, this strengthens the point of view concerning the necessity of carrying out the selection of cosmonaut candidates with high vestibular stability and the advisability of ground-based training during the preparatory period.

Ground-based simulation experiments of both domestic and foreign researchers, as well as the experience of manned space flights already conducted, testifiy to the complex effect of flight factors on the state of otorhinolaryngological organs.

Soviet cosmonauts and American astronauts, even during short flights, have repeatedly drawn attention to the substantial sonic burden on the auditory apparatus of the cosmonaut, who, while subjected to the constant effect of noise from the craft's systems, must also carry on two-way radio communication.

Analysis of the results of our studies during a year-long experiment with 62-

and 120-day hypokinesia allows one to assume the possibility of the appearance of changes in the human auditory system under the influence of certain factors of space flight. Against a background of asthenization and changes in the organism's reactivity in prolonged simulative experiments, fluctuations in auditory sensitivity were observed in healthy persons (within 20 db) and in the initial forms of cochlear neuritis, auditory thresholds to high tones rose from 35 to 50 db. Simultaneously, all of the subjects' thresholds of loudness discomfort dropped up to 35% from the original. 16

During a year-long experiment, it was shown that noise within the boundaries of hygienic norms, by virtue of the cumulative effect, evoked in some persons pronounced changes in the auditory organ. Thus, in one of three healthy subjects, the phenomenon of cochleitis was noted for a period of seven months after the experiment. In connection with this, [the following] acquire definite pressing interest: problems of setting standards for noise levels, study of the reaction of the human auditory system to the complex effect of flight factors, problems of forecasting the reliability of the auditory analysor . order to preserve a high work capability in the crew members, as well as the state of auditory sensitivity applicable to the problems of professional selection.

This fact necessitates the selection of candidates not only with good hearing, but the selection, by means of special tests for interference resistance, of persons with auditory systems highly resistant to noise loads.

Unfortunately, not one of the existing methods of audiometric study of the human auditory analysor allows sufficiently accurate forecasting of the "resistance" of the auditory system to the effect of prolonged noise, because heretofore the existence of a correlation between the degree of auditory exhaustion during selection tests and the tendency toward auditory "damage" during prolonged exposure to noise has not been proven.

In this respect, complex audiological and clinical-physiological examinatior

under conditions of a diurnal noise-load test appears encouraging (O. I. Kozerenko, Z. I. Matsnev, et al., 1967). [7]

Until the present, space medicine has not had sufficient information concerning the nature of the clinical manifestations of any diseases of man in space, the specific features of the course of the disease, and the means of its treatment. A clinical analysis of experimental data during simulation of the effects of certain factors of space flight substantiate sufficiently convincingly the possibility of the existence of these features during pathology of the otorhinolaryngological organs as well.

During hypokinesia, and especially during prolonged experiments in [closed] chambers, the development of dystrophic changes in the mucous membrane of the upper respiratory tracts was observed against a background of [mucous membrane] hemostatic changes and vasomotor disorders. A subjective evaluation by the cosmonauts of the condition of the mucous membrane of the nose and pharynx, as well as the results of post-flight examinations, testify that space-flight factors can have an effect on the condition of the mucous membrane of the upper respiratory tracts. The reaction of the mucous membrane in the form of temporary catarrhal phenomena, vasomotor changes, [and] dryness were observed in the astronauts by American investigators (Berry, 1967). Similar reactions were also noted in Soviet cosmonauts after flight.

It is well known that the main mechanism for the redistribution of blood during weightlessness creates preconditions for the distorted course of vasomotor disorders of the mucous membrane of the nose without any symptoms of inflammation. Because of this, during post-flight examination, phenomena of puffiness, blueness of the nasal conchae and objectively recorded symptoms of vasomotor changes in the nasal mucous membrane were often observed in the cosmonauts (I. I. Bryanov et al., 1970).

It is also appropriate to dwell on the tonsillar problem in space medicine,

which has not lost its urgency. Clinical observation of the cosmonauts has shown /8
that compensated forms of chronic tonsillitis, under the influence of a special preparation, have a definite tendency to make the process more acute. Similar facts have been observed repeatedly during prolonged simulation experiments as well.

These facts necessitate the introduction of a correction into the expert medical approach to this pathology and the broader recommendation of prophylactic tonsillectomy of the candidate prior to their inclusion into the training group.

At present, definite factual material has been accumulated which makes it possible to verify the possibility of the onset of other otorhinolaryngological pathology in candidates and cosmonauts, which requires the carrying out of therapeutic measures. Often, therapeutic measures prove to be even forced, since they are dictated by expert medical requirements.

The problem of allergy assumed particular importance. Allergic lesions to otorhinolaryngological organs can only disrupt the work capability of the crew, but also can become the reason for immediate necessary surgical intervention (glottidial edema) and even the unscheduled landing of the craft.

In connection with this, the conduction of allergological examination during selection [and] in the process of cosmonaut training acquires great importance, as does the pre-flight determination of individual sensitivity of the crew members to many preparations in the first-aid supplies.

Problems of the prophylaxis of aspirations also deserve close attention, since the possibilities of their onset increase in weightlessness.

Methodology of treating diseases of the otorhinolaryngological organs also ac- /9
quires a definite specific importance. In particular, in space flight even the traditional use of drops must be excluded in connection with the peculiarities of the situation and the transportation of liquids in weightlessness. This also concerns many other otorhinolaryngological procedures (instillation, bathing, etc.). Even the use of widely accepted methods of otorhinolaryngological endoscopy requires the acquisition of definite work habits in weightlessness and perfection of

the appratus and intrumentation.

However, the rendering of immediate, timely aid will depend not only on the presence of the necessary instrumental equipment, but also on the ability of the physician or someone of the crew members to render the appropriate medical aid and, specifically, otorhinolaryngological aid. This circumstance necessitates the inclusion, in the cosmonauts' training system, of a special section with otorhinolaryngological emphasis.

Thus, the problem arises of not only studying the space specifics of otorhinolaryngological diseases, but also modifying the diagnostic instruments and methods applicable to flight conditions. Perfection of these methods and constructive decisions concerning instrumental equipment must be made, very likely, not only in experiments on earth, but also in the actual conditions of flight, in particular, on orbital stations. From the data presented, it is evident that the problems of otorhinolaryngological support on prolonged space flights are complex and multifaceted. Their solution requires the creation of a specialized otorhinolaryngological trend in space medicine.

The main otorhinolaryngological aspects of space medicine, presented [here] /10
only in the most general terms, undoubtedly do not exhaust the total complexity of the problems which it will be necessary to decide during selection, training and medical support of prolonged flights.

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